DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)
16.2 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

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IMPORTANT NOTE REGARDING THESE INSTRUCTIONS

THESE INSTRUCTIONS ONLY APPLY TO PROPOSALS SUBMITTED IN RESPONSE TO DARPA 16.2 PHASE I TOPICS.

Offerors responding to DARPA topics listed in Section 12.0 of this Solicitation must follow all the instructions provided in the DoD Program Solicitation AND the supplementary DARPA instructions contained in this section. The section/paragraph numbering in these instructions is intended to correspond with the section/paragraph numbering of the 16.2 DoD Program Solicitation (http://www.acq.osd.mil/osbp/sbir/index.shtml).

Solicitation Closing Date: June 22, 2016, at 6:00 a.m. ET

1.0 INTRODUCTION

DARPA's mission is to prevent technological surprise for the United States and to create technological surprise for its adversaries. The DARPA SBIR Program is designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities.

The responsibility for implementing DARPA's Small Business Innovation Research (SBIR) Program rests with the Small Business Programs Office.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Attention: DIRO/SBPO
675 North Randolph Street
Arlington, VA 22203-2114
sbir@darpa.mil
http://www.darpa.mil/work-with-us/for-small-businesses

System Requirements

Use of the DARPA SBIR/STTR Information Portal (SSIP) is MANDATORY. Offerors will be required to authenticate into the SSIP (via the DARPA Extranet) to retrieve their source selection decision notice, to request debriefings, and to upload reports (awarded contracts only). DARPA SBPO will automatically create an extranet account for new users and send the SSIP URL, authentication credentials, and login instructions AFTER the 16.2 source selection period has closed. DARPA extranet accounts will ONLY be created for the individual named as the Corporate Official (CO) on the proposal coversheet. Offerors may not request accounts for additional users at this time.

WARNING: The Corporate Official (CO) e-mail address (from the proposal coversheet) will be used to create a DARPA Extranet account. Updates to Corporate Official e-mail after proposal submission may cause significant delays to communication retrieval and contract negotiation (if selected). Additional information in section 4.0.

3.0 DEFINITIONS

3.4 Export Control

The following will apply to all projects with military or dual-use applications that develop beyond fundamental research (basic and applied research ordinarily published and shared broadly within the scientific community):

(1) The Contractor shall comply with all U. S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of (including deemed exports) hardware, technical data, and software, or for the provision of technical assistance.

(2) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at any Government installation (whether in or outside the United States), where the foreign person will have access to export-controlled technologies, including technical data or software.

(3) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.

(4) The Contractor shall be responsible for ensuring that the provisions of this clause apply to its subcontractors.

Please visit http://www.pmddtc.state.gov/regulations_laws/itar.html for more detailed information regarding ITAR/EAR requirements.

3.5 Foreign National

Foreign Nationals (also known as Foreign Persons) means any person who is NOT:

a. a citizen or national of the United States; or
b. a lawful permanent resident; or
c. a protected individual as defined by 8 U.S.C. § 1324b

ALL offerors proposing to use foreign nationals MUST follow section 5.4. c.(8) of the DoD Program Solicitation and disclose this information regardless of whether the topic is subject to ITAR restrictions. There are two ways to obtain U.S. citizenship: by birth or by naturalization. Additional information regarding U.S. citizenship is available at https://travel.state.gov/content/travel/en/legal-considerations/us-citizenship-laws-policies.html. Definitions for "lawful permanent resident" and "protected individual" are available under section 3.5 of the DoD Program Solicitation.

4.0 PROPOSAL FUNDAMENTALS

4.6 Classified Proposals

DARPA topics are unclassified; however, the subject matter may be considered to be a "critical technology" and therefore subject to ITAR/EAR restrictions. See **Export Control** requirements above in Section 3.1.

4.7/4.8 Human or Animal Subject Research

DARPA discourages offerors from proposing to conduct Human or Animal Subject Research during Phase I due to the significant lead time required to prepare the documentation and obtain approval, which will delay the Phase I award. See sections 4.7 and 4.8 of the DoD Program Solicitation for additional information.

4.10 Debriefing

DARPA will provide a debriefing to the offeror in accordance with Federal Acquisition Regulation (FAR) 15.505. The source selection decision notice (reference 4.4 Information on Proposal Status) contains instructions for requesting a proposal debriefing. Please also refer to section 4.10 of the DoD Program Solicitation.

Notification of Proposal Receipt

Within 5 business days after the solicitation closing date, the individual named as the "Corporate Official" on the Proposal Cover Sheet will receive a separate e-mail from sbir@darpa.mil acknowledging receipt for each proposal received. Please make note of the topic number and proposal number for your records.

Notification of Proposal Status

The source selection decision notice will be available no later than **90 days after solicitation close.** The individual named as the "Corporate Official" on the Proposal Cover Sheet will receive an email for each proposal submitted, from sbir@darpa.mil with instructions for retrieving their official notification from the SSIP. Please read each notification carefully and note the proposal number and topic number referenced. The CO must retrieve the letter from the SSIP 30 days from the date the e-mail is sent. After 30 days the CO must make a written request to sbir@darpa.mil for source selection decision notice. The request must explain why the offeror was unable to retrieve the source selection decision notice from the SSIP within the original 30 day notification period. Please also refer to section 4.0 of the DoD Program Solicitation.

4.11 Solicitation Protests

Interested parties may have the right to protest this solicitation by filing directly with the agency by serving the Contracting Officer (listed below) with the protest, or by filing with the Government Accountability Office (GAO). If the protest is filed with the GAO, a copy of the protest shall be received in the office designated below within one day of filing with the GAO. The protesting firm shall obtain written and dated acknowledgment of receipt of the protest.

Agency protests regarding the solicitation should be submitted to:
SBIR/STTR Solicitation Contracting Officer
WHS/Acquisition Directorate
1155 Defense Pentagon
Washington, DC 20301-1155
E-mail: james.l.colachis.civ@mail.mil

Agency protests regarding the source selection decision should be submitted to:
DARPA
Contracts Management Office (CMO)
675 N. Randolph Street
Arlington, VA 22203
E-mail: scott.ulrey@darpa.mil and sbir@darpa.mil

4.13 Phase I Award Information

a. Number of Phase I Awards. DARPA reserves the right to select and fund only those proposals considered to be of superior quality and highly relevant to the DARPA mission. As a result, DARPA may fund multiple proposals in a topic area, or it may not fund any proposals in a topic area.

b. Type of Funding Agreement. DARPA Phase I awards will be Firm Fixed Price contracts.
c. Dollar Value. The maximum dollar value for a DARPA Phase I award shall not exceed $155,000.
d. Timing. The DoD goal for Phase I award is within 180 calendar days from the proposal receipt deadline. Phase I contract award may be delayed if the offeror fails to include sufficient documentation to support its cost proposal.

4.22 Discretionary Technical Assistance (DTA)

DARPA has implemented the Transition and Commercialization Support Program (TCSP) to provide commercialization assistance to SBIR and/or STTR awardees in Phase I and/or Phase II. Offerors awarded funding for use of an outside vendor for discretionary technical assistance (DTA) are excluded from participating in TCSP.

DTA requests must be explained in detail with the cost estimate and provide purpose and objective (clear identification of need for assistance), provider's contact information (name of provider; point of contact; details on its unique skills/experience in providing this assistance), and cost of assistance (clearly identified dollars and hours proposed or other arrangement details). The cost cannot be subject to any profit or fee by the requesting firm. In addition, the DTA provider may not be the requesting firm itself, an affiliate or investor of the requesting firm, or a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g., research partner).

Offerors proposing DTA must complete the following:

1. Indicate in question 17, of the proposal coversheets, that you request DTA and input proposed cost of DTA (in space provided).
2. Provide a one-page description of the vendor you will use and the technical assistance you will receive. The description should be included as the LAST page of the Technical Volume. This description will not count against the 20-page limit of the technical volume and will NOT be evaluated.
3. Enter the total proposed DTA cost, which shall not exceed $5,000, under the "Discretionary Technical Assistance" line along with a detailed cost breakdown under "Explanatory material relating to the cost proposal" via the online cost proposal.

Approval of DTA is not guaranteed and is subject to review of the Contracting Officer. Please see section 4.22 of the DoD Program Solicitation for additional information.

5.0 PHASE I PROPOSAL

Phase I Option

DARPA has implemented the use of a Phase I Option that may be exercised to fund interim Phase I activities while a Phase II contract is being negotiated. Only Phase I companies selected for Phase II will be eligible to exercise the Phase I Option. The Phase I Option covers activities over a period of up to four months and should describe appropriate initial Phase II activities that may lead to the successful demonstration of a product or technology. The statement of work for the Phase I Option counts toward the 20-page limit for the Technical Volume.

5.4.c.(6) Commercialization Strategy

DARPA is equally interested in dual use commercialization of SBIR project results to the U.S. military, the private sector market, or both, and expects explicit discussion of key activities to achieve this result in the commercialization strategy part of the proposal.

Technology commercialization and transition from Research and Development activities to fielded systems within the DoD is challenging. Phase I is the time to plan for and begin transition and commercialization activities. The small business must convey an understanding of the preliminary transition path or paths to be established during the Phase I project.

The Phase I commercialization strategy shall not exceed 5 pages, and will NOT count against the 20-page proposal limit. The commercialization strategy should include the following elements:
1. Problem or Needs Statement. Briefly describe the problem, need, or requirement, and its significance relevant to a DoD application and/or a private sector application that the SBIR project results would address.
2. Potential Product(s), Application(s), and Customer(s). Identify potential products and applications, DoD end-users, Federal customers, and/or private sector customers who would likely use the technology.
3. Business Model and Funding. Include anticipated business model; potential private sector and federal partners the company has identified to support transition and commercialization activities; and the Technology Readiness Level (TRL) expected at the end of the Phase I.
4. Preliminary Phase II Strategy. Include key proposed milestones anticipated during Phase II such as: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.
5. Advocacy Letters (OPTIONAL).* Feedback received from potential Commercial and/or DoD customers and other end-users regarding their interest in the technology to support their capability gaps. Advocacy letters that are faxed or e-mailed separately will NOT be accepted.
6. Letters of Intent/Commitment (OPTIONAL).* Relationships established, feedback received, support and commitment for the technology with one or more of the following: Commercial customer, DoD PM/PEO, a Defense Prime, or vendor/supplier to the Primes and/or other vendors/suppliers identified as having a potential role in the integration of the technology into fielded systems/products or those under development. Letters of Intent/Commitment that are faxed or e-mailed separately will NOT be accepted.

***Advocacy Letters and Letters of Intent/Commitment are optional, and should ONLY be submitted to substantiate any transition or commercialization claims made in the commercialization strategy. Please DO NOT submit these letters just for the sake of including them in your proposal. These letters DO NOT count against any page limit.**

Please note: In accordance with section 3-209 of DOD 5500.7-R, Joint Ethics Regulation, letters from government personnel will NOT be considered during the evaluation process.

5.5 Phase I Proposal Checklist

Complete proposals must contain the following elements. Incomplete proposals will be rejected.

____ 1. Volume 1: Completed Coversheet.

  ____ a. Completed and checked for accuracy.

  ____ b. Costs for the base and option (if proposed) are clearly separate and identified on the Proposal Cover Sheet.

____ 2. Volume 2: Technical Volume.

____ a. Numbered all pages of the proposal consecutively. The cover sheets are pages 1 and 2. The technical volume begins on page 3.

____ b. Font type is no smaller than 10-point on standard 8½" x 11" paper with one-inch margins. The header on each page of the technical proposal contains the company name, topic number and proposal number assigned by the DoD SBIR/STTR Electronic Submission Web site when the cover sheet was created. The header may be included in the one-inch margin.

____ c. Include documentation required for Discretionary Technical Assistance (if proposed).

____ d. The technical volume (not including the commercialization strategy) does not exceed twenty (20) pages. Any page beyond 20 will be redacted prior to evaluations.

____ 3. Volume 3: Cost Volume.

____ a. Used the online cost proposal.

____ b. Subcontractor, material and travel costs in detail. Used the "Explanatory Material Field" in the DoD Cost Volume worksheet for this information, if necessary.

____ c. Costs for the base and option (if proposed) are clearly separate and identified in the Cost Volume.

____ d. Base effort does not exceed $100,000 or $105,000 if DTA services are proposed.

____ e. Option (if proposed) does not exceed $50,000.

____ f. If proposing DTA, cost submitted in accordance with instructions in section 4.22 and does not exceed $5,000.

____ 4. Volume 4: Company Commercialization Report

____ a. Completed and checked for accuracy. Follow requirements specified in section 5.4(e).

____ 5. Submission

____ a. Upload four completed volumes: Volume 1: Proposal Cover Sheet; Volume 2: Technical Volume; Volume 3: Cost Volume; and Volume 4: Company Commercialization Report electronically through the DoD submission site by the solicitation closing date.

____ b. Review your submission after upload to ensure that all pages have transferred correctly and do not contain unreadable characters. Contact the DoD Help Desk immediately with any problems (see section 4.15).

____ c. Submit your proposal before 6:00 A.M. on the solicitation closing date. DARPA will NOT accept proposals that have NOT been submitted by the solicitation deadline.

6.0 PHASE I EVALUATION CRITERIA

Phase I proposals will be evaluated in accordance with the criteria in section 6.0 of the DoD Program Solicitation.

The offeror's attention is directed to the fact that non-Government advisors to the Government may review and provide support in proposal evaluations during source selection. Non-government advisors may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. These advisors will not establish final assessments of risk and will not rate or rank offeror's proposals. They are also expressly prohibited from competing for DARPA SBIR or STTR awards in the SBIR/STTR topics they review and/or provide comments on to the Government. All advisors are required to comply with procurement integrity laws and are required to sign Non-Disclosure Agreements and Rules of Conduct/Conflict of Interest statements. Non-Government technical consultants/experts will not have access to proposals that are labeled by their offerors as "Government Only".

Limitations on Funding

DARPA reserves the right to select and fund only those proposals considered to be of superior quality and highly relevant to the DARPA mission. As a result, DARPA may fund multiple proposals in a topic area, or it may not fund any proposals in a topic area. Phase I awards and options are subject to the availability of funds.

7.0 PHASE II PROPOSAL

All offerors awarded a Phase I contract under this solicitation will receive a notification letter with instructions for preparing and submitting a Phase II Proposal and a deadline for submission. Visit http://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program for more information regarding the Phase II proposal process.

11.0 CONTRACTUAL CONSIDERATIONS

11.1(r) Publication Approval (Public Release)

National Security Decision Directive (NSDD) 189 established the national policy for controlling the flow of scientific, technical, and engineering information produced in federally funded fundamental research at colleges, universities, and laboratories. The directive defines fundamental research as follows: "Fundamental research" means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons.

It is DARPA's goal to eliminate pre-publication review and other restrictions on fundamental research except in those exceptional cases when it is in the best interest of national security. Please visit http://www.darpa.mil/about-us/public-affairs for additional information and applicable publication approval procedures.

11.4 Patents

Include documentation proving your ownership of or possession of appropriate licensing rights to all patented inventions (or inventions for which a patent application has been filed) that will be utilized under your proposal. If a patent application has been filed for an invention that your proposal utilizes, but the application has not yet been made publicly available and contains proprietary information, you may provide only the patent number, inventor name(s), assignee names (if any), filing date, filing date of any related provisional application, and a summary of the patent title, together with either: (1) a representation that you own the invention, or (2) proof of possession of appropriate licensing rights in the invention. Please see section 11.4 of the DoD Program Solicitation for additional information.

11.5 Intellectual Property Representations

Provide a good faith representation that you either own or possess appropriate licensing rights to all other intellectual property that will be utilized under your proposal. Additionally, proposers shall provide a short summary for each item asserted with less than unlimited rights that describes the nature of the restriction and the intended use of the intellectual property in the conduct of the proposed research. Please see section 11.5 of the DoD Program Solicitation for information regarding technical data rights.

11.7 Phase I Reports

All DARPA Phase I awardees are required to submit reports in accordance with the Contract Data Requirements List – CDRL and any applicable Contract Line Item Number (CLIN) of the Phase I contract. Reports must be provided to the individuals identified in Exhibit A of the contract. Please also reference section 4.0 of the DoD Program Solicitation.

Direct to Phase II

15 U.S.C. §638(cc), as amended by NDAA FY2012, Sec. 5106, PILOT TO ALLOW PHASE FLEXIBILITY, allows the DoD to make an award to a small business concern under Phase II of the SBIR program with respect to a project, without regard to whether the small business concern was provided an award under Phase I of an SBIR Program with respect to such project.

DARPA is conducting a "Direct to Phase II" pilot implementation of this authority for this 16.2 SBIR Solicitation only and does not guarantee the pilot will be offered in future solicitations.

Not all DARPA topics are eligible for a Direct to Phase II award. Potential offerors should read the topic requirements carefully. Topics may accept Phase I and Direct to Phase II proposals, Phase I proposals only, or Direct to Phase II proposals only – refer to the 16.2 Topic Index to review proposal types accepted against each topic. DARPA reserves the right to not make any awards under the Direct to Phase II pilot. All other instructions remain in effect. Direct to Phase II proposals must follow the instructions in the DARPA Direct to Phase II Solicitation Instructions.

DARPA SBIR 16.2 Topic Index

*These instructions **ONLY** apply to Phase I Proposals. **For Direct to Phase II, refer to the DARPA 16.2 Direct to Phase II (DP2) Topics and Proposal Instructions** available at (http://www.acq.osd.mil/osbp/sbir/index.shtml).*

Proposals Types Accepted

Topic	Topic Title	Phase I	DP2
SB162-001	Real-time Assessment of Antimicrobial Concentrations for Personalized Treatment of Infectious Diseases	YES	YES
SB162-002	Point-of-care Monitoring of the Host-Pathogen Interaction during Infection	YES	YES
SB162-003	Next Generation Research Tools for Understanding Human Social Systems	YES	YES
SB162-004	Secure Messaging Platform	YES	YES
SB162-005	Managing Emergent Behavior of Interacting Autonomous Systems	YES	YES
SB162-006	Innovative Technologies for High Power Amplification at THz frequencies	YES	YES
SB162-007	Integrated Interface Layer for Micromagnetics and RF Computational Engines	YES	YES
SB162-008	Distributed Coherent Communications	YES	YES
SB162-009	Software/Analytics Exploiting Commercial Satellite Imagery	YES	YES
SB162-010	Near-Photon-Counting, High Dynamic Range, Passive Vision Detector Arrays	YES	YES
SB162-011	Distributed, Large Scale Spectrum Measurement and Analysis	YES	YES
SB162-012	Complementary Piezo Energy Harvesting for Small Satellites in Eclipse	YES	NO
SB162-013	Telemetry Buoy - TM Collection System	YES	NO
SB162-014	Light-weight and Low Cost Composite Cryotank	YES	YES
SB162-015	Autonomous Detection of Near-Surface Marine Mammals	YES	YES

DARPA SBIR 16.2 Topic Descriptions

SB162-001 TITLE: Real-time Assessment of Antimicrobial Concentrations for Personalized Treatment of Infectious Diseases

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Biomedical, Materials/Processes

OBJECTIVE: Develop a real-time device capable of measuring small-molecule antibiotic drug concentrations from a small quantity of blood in less than 30 minutes. The application of this technology would be improved and personalized antibiotic administration, which would diminish the likelihood of the development of antimicrobial resistance.

DESCRIPTION: There is an urgent DoD need to optimize antimicrobial dosing to address the prevalence of drug-resistant pathogens and the increase of minimum inhibitory concentrations (MICs) of antimicrobials. Recent evidence suggests that current antimicrobial dosing may be inadequate for some critically ill patients. Specifically, variable metabolism of antibiotics due to the patient's current state of illness, as well as heterogeneity among patients in the metabolism and antimicrobials, lead to substantial fluctuations in levels. The ability to measure drug concentrations in near real-time would greatly facilitate treatment and reduce the risk of administering suboptimal doses of antimicrobials. Unfortunately, the reliance on laboratory-scale equipment such as high-performance liquid chromatography (HPLC) to quantify drug concentrations precludes measurement at the point of care.

PHASE I: Develop a benchtop breadboard device to demonstrate feasibility of approach. Deliverables will include a detailed device design plan, regulatory plan, Phase II commercialization strategy, and Phase I final report.

PHASE II: Compare the performance of the breadboard device developed in Phase I with gold standard testing (e.g., HPLC) to determine the performance characteristics of the system in an in vitro and in vivo small animal model. Modify the approach to ensure that the device meets the minimum specifications outlined below. In addition, develop and implement a design-for-manufacturability strategy. Deliverables will include ten standalone prototype devices suitable for user evaluation, and Phase II final report.

The device prototype will be required to meet the following specifications:
• Antimicrobials of Interest: Amphotericin; Voriconazole; Colistin; Gentamicin; Meropenem (1 specimen per test)
• Specimen Matrix: Blood (< 50 µL drop)
• Limit of Detection: Dependent on drug (specify & justify in proposal)
• Dynamic Range: Dependent on drug (specify & justify in proposal)
• Error and Uncertainty: Specify & justify in proposal (compared to gold standard measurement and across multiple measurements)
• Test Turnaround Time (TAT): < 30 minutes
• Ease of Use: Low complexity; < 5 steps by user with one timed step requiring < 5 minutes of user intervention
• User Interface: Results displayed on screen with capability to save and recall previous results
• Power: AC and battery (> 8 hour lifetime; > 15 tests between charges)
• Training: Minimal; instructions and graphical aides sufficient for user operation
• Storage: Reagents do not require cold-chain and shelf stable > 12 months
• Form Factor: Handheld device for sample preparation and measurement
• Communications Interface: USB with computer for data upload/download

The ultimate device may be comprised of a disposable component containing the reagents and a non-disposable component (e.g., pumps, power supply, electronics etc.). The device form factor should be suitable for use at the point of care by a nurse or physician, similar to commercially available glucose meters. Sample preparation by the user should be minimal and all reagents required should be self-contained within a disposable component and not require refrigeration. The device should accept specimens from the patient using standard clinical methods (e.g., finger prick or venous whole blood).

PHASE III DUAL USE APPLICATIONS: A clear plan towards FDA approval for the device should be implemented and additional testing to meet FDA requirements will be completed. Additional funding may be provided by DoD sources, but the awardee must also look toward other government or civilian funding sources to continue the process of translation and commercialization. If successful, this device would have clinical utility in both civilian and military settings. Acquisition customers include the US Army Medical Research and Materiel Command (MRMC) and Defense Health Agency (DHA).

REFERENCES:
1. Akers, KS. Colistin Pharmacokinetics in Burn Patients during Continuous Venovenous Hemofiltration. Antimicrobial Agents and Chemotherapy 59, 46-52 (2015).

2. Ferguson, BS. Real-Time, Aptamer-Based Tracking of Circulating Therapeutic Agents in Living Animals. Science Translational Medicine 5, 213ra165 (2013).

3. Wong, G. How do we use therapeutic drug monitoring to improve outcomes from severe infections in critically ill patients? BMC Infectious Diseases 14, 288-299 (2014).

KEYWORDS: Therapeutic drug monitoring; point-of-care test; drug concentration; biosensor; personalized medicine

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SB162-002 TITLE: Point-of-care Monitoring of the Host-Pathogen Interaction during Infection

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop point-of-care technologies to monitor and characterize host-pathogen interactions during acute severe infection.

DESCRIPTION: There is a critical DoD need to develop a system that could be used at the point of care for monitoring in near real time host-pathogen interactions that would enable personalized therapeutic interventions during acute severe infection. Proposed approaches must go beyond traditional techniques for diagnosis based on microbiological testing, clinical signs, symptoms, and physiology to enable more targeted and appropriate interventions. Parameters of interest include, but are not limited to nucleic acids, cytokines, coagulation factors, hemopexin, and pathogen-associated molecular pattern (PAMP) molecules. The proposed technique must be capable of frequently measuring analytes and be in a format suitable for point-of-care use. During the course of severe clinical infection, the fluctuating status of patients requires frequent monitoring that ultimately informs treatment. Patient outcomes are determined by the invading pathogen(s), subsequent host response, and therapeutic intervention. For example, sepsis arises from an exuberant host response to infection that results in collateral organ and tissue damage. This syndrome represents a major health challenge and is one of the most common causes for admission into intensive care units (ICU). Blood culture is considered the gold standard for diagnosis and identification of pathogens in the bloodstream, but is insensitive and suffers from a long turnaround time.

PHASE I: Demonstrate feasibility of the approach in a breadboard configuration. A detailed design and manufacturing plan, animal testing plan, regulatory plan, and commercialization strategy shall be delivered with the final report.

PHASE II: Develop prototypes of the system. The performance characteristics of the system shall be evaluated using clinically relevant samples. Manufacturing of the system should be done under GMP conditions. A regulatory package should be drafted with the requisite supporting information. The device prototype will be required to meet the following specifications:

• Specimen Matrix: Blood (< 50 µL drop)
• Limit of Detection: Dependent on analyte (specify & justify in proposal)
• Dynamic Range: Dependent on analyte (specify & justify in proposal)
• Error and Uncertainty: Specify & justify in proposal (compared to gold standard measurement and across multiple measurements)
• Test Turnaround Time (TAT): < 30 minutes
• Ease of Use: Low complexity; < 5 steps by user with one timed step requiring < 5 minutes of user intervention
• User Interface: Results displayed on screen with capability to save and recall previous results
• Power: AC and battery (> 8 hour lifetime; > 15 tests between charges)
• Training: Minimal; instructions and graphical aides sufficient for user operation
• Storage: Reagents do not require cold-chain and shelf stable > 12 months
• Form Factor: Handheld device for sample preparation and measurement
• Communications Interface: USB with computer for data upload/download

PHASE III DUAL USE APPLICATIONS: A clear plan towards FDA approval for the device should be implemented and additional testing to meet FDA requirements will be completed. Additional funding may be provided by DoD sources, but the awardee must also look toward other government or civilian funding sources to continue the process of translation and commercialization. If successful, this device would have clinical utility in both civilian and military settings. Acquisition customers include the US Army Medical Research and Materiel Command (MRMC) and Defense Health Agency (DHA).

REFERENCES:
1. Jain, A. A shear gradient-activated microfluidic device for automated monitoring of whole blood haemostasis and platelet function. Nature Communications 7 (2016).

2. Kellum, JA. Understanding the inflammatory cytokine response in pneumonia and sepsis. Arch Internal Medicine 15, 1655 – 1663 (2007).

3. McHugh, L. A molecular host response assay to discriminate between sepsis and infection-negative systemic inflammation in critically ill patients: Discovery and validation in independent cohorts. PLoS Medicine 12, 1 – 35 (2015).

4. Oved, K. A novel host-proteome signature for distinguishing between acute bacterial and viral infections. PLoS One 10, 1 – 18 (2015).

5. Service, RF. Will biomarkers take off at last? Science 321, 1760 (2008).

6. Taslik, EL. Host gene expression classifiers diagnose acute respiratory illness etiology. Science Translational Medicine 8, 322ra11 (2016).

KEYWORDS: Host-pathogen interaction; point-of-care; prognostic; diagnostic; pathogen-associated molecular pattern (PAMP) molecules; nucleic acid detection; hemopexin; cytokines

TPOC-1: Dr. Matthew Hepburn
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SB162-003 TITLE: Next Generation Research Tools for Understanding Human Social Systems

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Human Systems, Information Systems

OBJECTIVE: Develop tools to support innovation in advancing best practice research methods and capabilities for the social, behavioral, and economic (SBE) sciences, which include, but not limited to: analysis software, workflow systems, statistical packages, experimental platforms, and others.

DESCRIPTION: There is a critical DoD need for accurate and robust, reliable social, behavioral, and economic (SBE) models, which are increasingly important for planning and conducting effective military operations, including humanitarian aid, disaster relief, and stability support missions. The SBE sciences provide essential theories and frameworks that shape understanding of a wide range of human social behavior and systems of relevance for national security. The validity and reliability of SBE theories and concepts are fundamental to strong tactical, operational, strategic, and policy-level decision-making across the Department of Defense.

In light of several widely recognized “crises” in reproducibility in a number of disciplines, there is increased appreciation for the importance – and challenge – of experimentally validating results and claims of theories or model predictions. The academic community has responded by identifying a wide range of biases in the published literature, as well as their sources in experimental, statistical, and institutional structures and practices. Fortunately, a number of best practices and innovative methods have been developed to mitigate some of these challenges – but there remain opportunities for further development and dissemination of tools that, if matured and adopted, could have significant positive impact on a wide range of research questions and communities in SBE.

Accordingly, this topic is soliciting proposals for innovative tools that could demonstrate this positive impact. Examples might include proposals that provide credible approaches to improve the speed, efficiency, cost and/or adoption of one or more of the following tools: methods for pre-registration of experimental protocols; tools for transparent, modular, dynamic, and portable informed consent; Bayesian Net tools for tracking contingent evidentiary support structures within complex data or experimental designs; statistical tools to help identify and mitigate different biases in published or unpublished research; meta-analytic tools for exploring the robustness and generalizability of empirical findings; extensible packages for the analysis of text or geocoded data; assimilation methods for tuning computational models using real-time observations; licensing models for ethical data-sharing that protects Personally Identifiable Information (PII); platforms for joint collaboration and design of experimental protocols to increase scientific value prior to data collection; methods to obtain institutional pre-approval of widely-used experimental platforms like online surveys or games; and platforms that ethically and cost-effectively recruit a large number of experimental subjects across a wide range of cultural and demographic variables.

This topic is generally not seeking to fund approaches that are tightly tied to narrow experimental protocols or sensor systems, rely on restricted or excessively costly software and/or data sets, or visualization tools not explicitly tied to reproducible analytic techniques. Hardware and sensor approaches should leverage widely-available existing platforms and any proposed development efforts must focus on range of application, ease of use, and low barriers of entry for adoption of the tool or tools by academic, government, and commercial SBE researchers.

PHASE I: Identify the target research practice, protocol, or method that will be improved by the tool, and justify your approach via detailed specification of the degree of improvement over current practice, or a description of the new capabilities afforded. Demonstrate the key technical principles behind the proposed solution, and identify mitigations for any barriers to scale. The demonstrations should show wide applicability and relevance and potential benefit for common methodological approaches or challenges in the SBE sciences. Phase I deliverables are a notional prototype that achieves the core functionality of the complete product, as well as an extensive commercialization/propagation plan for achieving widespread use, and a final report.

PHASE II: Demonstrate scale and usability of the proposed approach. The demonstration should validate the predicted improvements and/or new capabilities versus current state of practice, as well as the engineering and design work required to easily scale. This includes integrations into existing systems and the development of institutional partnerships. The Phase 2 deliverables include the prototype system and a final report that includes the demonstration system design and test results.

PHASE III DUAL USE APPLICATIONS: Commercial applications may include product development, collaboration and workforce productivity tools, privacy enhancement, business intelligence, and data management. Military applications may include rapid ethnographic assessment, mission planning and logistics, crisis response and disaster relief.

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KEYWORDS: social sciences, statistics, analysis, research practice, psychology, economics, behavioral science, data security

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SB162-004 TITLE: Secure Messaging Platform

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Create a secure messaging and transaction platform that separates the message creation, from the transfer (transport) and reception of the message using a decentralized messaging backbone to allow anyone anywhere the ability to send a secure message or conduct other transactions across multiple channels traceable in a decentralized ledger.

DESCRIPTION: There is a critical DoD need to develop a secure messaging and transaction platform accessible via web browser or standalone native application. The platform separates the message creation, from the transfer of the message within a secure courier to the reception and decryption of the message.

Legacy messaging and backoffice infrastructures, traditionally based on centralized, unencrypted hub-and spoke database architecture, are expensive, inefficient, brittle and subject to cyber attack. The overhead costs of maintaining such architectures is rising rapidly. Many organizations unknowingly keep duplicate information and fail to ensure synchronization thus amplifying the potential for data theft and data corruption/rot. Incorporating a truly transparent mechanism for conducting journaled transactions enables the DoD to leverage its distributed footprint for a reduction in latency of these transactions, their security and their integrity and assurance.

The messaging platform will transfer messages via a secure decentralized protocol that will be secured across multiple channels, including but not limited to: 1) Transport protocol, 2) Encryption of messages via various application protocols, 3) Customized blockchain implementation of message deconstruction and reconstruction, and decentralized ledger implementation. With this messaging platform the business logic of the DoD ecosystem would be mapped onto a network of known entities using distributed ledgers. By doing this significant portions of the DoD backoffice infrastructure can be decentralized, 'smart documents and contracts' can be instantly and securely sent and received thereby reducing exposure to hackers and reducing needless delays in DoD backoffice correspondence. As an example, Military Interdepartmental Purchase Requests (MIPR) could be implemented using the secure ledger. Regulators with access to the ledger could read the correspondence and thus easily verify that a MIPR transaction didn't violate Federal Acquisition Regulations (FAR).

The messaging platform would act as the transport for a cyptographically sound record of all transactions whether they be MIPRs, contracts, troop movements or intelligence. Troops on the ground in denied communications environments would have a way to securely communicate back to HQ and DoD back office executives could rest assured that their logistics system is efficient, timely and safe from hackers. The benefits are broad and could even be applied to domains such as space. With crowded skies it's important to maintain situational awareness of all satellites and those concerned with space situational awareness/telemetry or air traffic control could instantly share data between nations using a separate but equivalent ledger implementation thus removing questions as to the authenticity and integrity of the data.

PHASE I: Create a specific decentralized messaging platform built on the framework of an existing blockchain framework. There are several layers of complexity that will be explored in this phase from the messaging platform, to transport protocol, to end user application. Phase 1 goals include: creating a model for the decentralized messaging platform, experimenting with encryption schemes, evaluating hardware to be used in combination with the messaging platform to provide additional security, and defining the product feature set from the application and platform perspectives and finally, developing a blueprint of the platform architecture mapped to DoD constructs.

PHASE II: Develop, test and evaluate a working prototype with the following features:
• Decentralized back end blockchain implementation
• Data aggregation, reconstruction
• Data transport protocol implementation
• End user application implementation (alpha)
• Conduct simulated MIPR transactions using the decentralized ledger
• Allow transparent regulatory review of DoD legal findings and contracts

• Significant reduction in time for regulatory overview of various transactions
• Tracking of aircraft or satellites with simulated telemetry or air traffic control data
• System Admin and Monitoring tools and engine
• Integration of hardware or edge of network hardware components

PHASE III DUAL USE APPLICATIONS: The DoD requires a secure messaging system that can provide repudiation or deniability, perfect forward and backward secrecy, time to live/self delete for messages, one time eyes only messages, a decentralized infrastructure to be resilient to cyber-attacks, and ease of use for individuals in less than ideal situations. Based on the outcomes and feedback from Phase 2, Phase 3 will focus on commercialization and full-scale implementation of the platform. This entails converting the alpha of the end user application into a beta application and increasing user testing and platform monitoring and industrializing the back-end platform in terms of decentralized ledger architecture and blockchain implementation.

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KEYWORDS: email, end-to-end encryption, privacy, security, secure messaging, repudiation, perfect forward secrecy

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SB162-005 TITLE: Managing Emergent Behavior of Interacting Autonomous Systems

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Battlespace, Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop meta-heuristic algorithms for the management of interacting autonomous agents by leveraging insights from highly resilient biological systems.

DESCRIPTION: Modern warfare requires reacting to ever-greater numbers of autonomous systems, not only in the form of vehicles, but also as agents working in cyber defense [1,2] and in social media [3,4]. As a result, there is a critical DoD need for the development of control strategies for groups of autonomous agents ("swarms"), in particular, strategies that would allow for resilient performance when interacting with other (friendly, neutral, or hostile) swarms employing their own, potentially unknown, strategies. Such interactions can lead directly to unexpected and potentially adverse emergent behaviors. The U.S. stock market “flash crash” of 2010 [5,6] is one example of adverse emergent behavior resulting from, in part, the interaction of autonomous agents with proprietary and largely unobservable internal workings.

In future joint operations, coordination of swarms will become a strict requirement to prevent unwanted emergent behavior. Similarly, managing interactions with neutral and adversarial autonomous agents in “gray zone” [7] and major combat operations will be essential. In all cases, the autonomous agents may be required to function and coordinate/manage interactions under a large variety of conditions without a robust model of their interacting partner or adversary systems. This lack of models makes the common modeling- and simulation-based approach to the design of autonomous system control strategies [8] less effective. An alternative approach is to focus on developing novel control strategies based on advanced meta-heuristic algorithms [9] that provide the necessary resilience to interactions with other systems.

Research into the social behavior of species such as wasps, ants, and bees [10-12] (as well as the collective behavior of cells [13], such as bacteria, yeast, and amoebae) has the potential to help identify useful such meta-heuristic control strategies, as they (a) exhibit strong parallels to autonomous agents, with processing and action at both individual and group levels [10], (b) necessarily and routinely engage in interactions within colonies, across colonies, across species, and across varied environments, and (c) have evolved highly resilient policies governing a number of forms of synchronized and coordinated behavior. The study of biological systems and their control strategies—which have evolved over millions of years to provide resilience in the face of a wide array of challenges—has already contributed significantly to computer science [14–17] and autonomous systems research [18–20].

Furthermore, research on non-vertebrate species can typically be done rapidly and at low cost, with established rigorous experimental practices for investigating specific classes of interactions. These biological systems therefore represent a vast natural library of meta-heuristic algorithms that could be used in the design of control strategies, and, in addition, can serve an experimental platform for investigating specific classes of interactions.

The focus of this work will be on leveraging research in biological systems to identify strategies and develop algorithms for coping with emergent behavior in shared environments with both competitive and non-competitive autonomous systems. Domains of interest include, but are not limited to: cyber defense, social media, data-mining, unmanned vehicles, and complex system design (see, e.g., [21]).

PHASE I: Define one or more compelling problem domains related to national security where swarms of autonomous agents interact in shared environments. Identify one or more non-vertebrate species (not subject to animal use guidelines) that can provide insights into the control of autonomous agents and provide detailed rationale for their selection. Develop experimental design for biological system study and conduct a pilot study. Prototype a software framework for testing, in simulation, algorithms embodying new meta-heuristic control strategies. Develop and demonstrate simple algorithms based on the result of the pilot study and/or prior research data, explicitly show the biological system basis for the strategies, and compare performance to existing algorithms. The Phase I final report will include an experimental plan to be executed under Phase II.

PHASE II: Execute the experimental plan developed under Phase I to study the most informative forms of interaction in the chosen species. Develop and demonstrate algorithms based on results of the experiments, explicitly show the biological basis for the strategies, and compare performance to existing strategies. Implement the software framework for testing, in simulation, algorithms embodying higher-level control strategies. Evaluate algorithms against existing state of the art, and demonstrate the biological system basis for the strategies. Identify target autonomous systems that could adopt resulting algorithms. Deliverables will include software (source code) and technical reports, and the Phase II final report with recommendations for transitioning the algorithms to operational systems.

PHASE III DUAL USE APPLICATIONS: The DoD has considerable interest in ensuring successful interoperation of autonomous systems (and systems of such systems) in joint operations with partner nations. Therefore, the goal during Phase III will be on transitioning algorithms to specific platforms and their respective programs of record, as well as transitioning the software framework for testing control strategies for use in laboratory environments. This will entail development of application-specific software, hardening the algorithms, and ensuring performance on application-specific hardware as well as in real-world and real-time environments.

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KEYWORDS: autonomous systems, swarms, control theory, bio-inspired computing, emergent behavior, animal models, self-organizing systems, artificial intelligence

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SB162-006 TITLE: Innovative Technologies for High Power Amplification at THz frequencies

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Electronics, Sensors

OBJECTIVE: Investigate and demonstrate an innovative and radical approach capable of revolutionizing technologies for high power amplification at terahertz (THz) frequencies.

DESCRIPTION: Vacuum electronic and solid state high power amplifiers are important technologies for a wide range of military, civilian, and commercial applications. Vacuum electronic amplifiers are based on electron beam transport in vacuum and are capable of high power amplification (gain over 40 dB), output power in the kW range, wide bandwidth (multi-octave), high reliability (100,000 hours), high efficiency (up to 90% with depressed collector), high radiation tolerance, and efficient heat dissipation. Solid state amplifier technologies are based on electron beam transport in semiconductors and tend to have higher reliability (one million hours), but with reduced output power in the range of tens to hundreds of watts and efficiency as high as 40% at microwave frequencies and below. Solid state technologies also exhibit less efficient heat dissipation that contributes to increased system size, weight, and power. Significant progress continues to be demonstrated in both technologies towards higher operating frequencies, bandwidth, and efficiency, although vacuum electronic devices still maintain an edge in applications requiring high power and efficiency at the highest frequencies.

The worldwide availability and proliferation of inexpensive, high power commercial amplifiers and sources has made the electromagnetic spectrum crowded and contested in the RF and microwave regions. The wealth of technical advantages offered by operating at higher frequencies, most notably the wide bandwidths available, are pushing both commercial and DoD solid-state and vacuum electron devices into the millimeter wave (mm-wave) region and beyond. However, pushing device operation to THz frequencies results in significant degradation in performance as the device dimensions decrease proportionally. For vacuum electronic amplifiers, the performance degradation is due to the constrained electron beam that must pass through much reduced interaction structures, as well as the challenging manufacturing and alignment tolerances. Similarly, solid state amplifier technologies suffer scaling challenges of their own that significantly limit their performance.

Researchers have demonstrated vacuum electronic amplifiers operating at 850 GHz with output power above 50 mW, 15 dB gain, and 11 GHz of bandwidth; and solid state amplifiers operating at 1 THz with output power to several milliwatts, 10 dB gain, and 90 GHz of bandwidth. However, the approaches demonstrated for both technologies are reaching their physical limits at THz frequencies. DARPA is seeking radical and innovative new approaches to fundamentally challenge the limitations imposed on power amplifier technologies at THz frequencies. At a minimum this approach will enable and enable, at the minimum, 1 W output power, 10 dB gain, 10% bandwidth, 50% power efficiency, and predicted reliability of one million hours; all in a reduced form factor for a single amplifier device. The proposed solution will provide technological advantage to military and commercial systems through increased accessibility to the regions of the electromagnetic spectrum that currently are unexplored.

The proposed approach must address all aspects of amplifier technology, including power supply and thermal management, necessary to demonstrate capabilities for high performance in a compact form factor at operating frequencies beyond 1 THz. Proposals must identify risks associated with the proposed innovative approach and present a thorough risk mitigation plan.

PHASE I: Demonstrate the feasibility of an innovative device concept capable of high power amplification enabling, at a minimum, operation at 1 THz with 1 W output power, 10 dB gain, 10% bandwidth, 50% power efficiency, and predicted reliability of one million hours from a single, compact device. Proposers will develop the initial concept design, identify key elements of the technology that will enable high performance, and perform complete analysis of the design using full-wave electromagnetic modeling and simulation. Deliverables will include a Phase I final report including a detailed plan for demonstrating a hardware prototype that can meet the performance metrics listed above.

PHASE II: Fabricate and test a single unit hardware prototype based on the Phase I concept and demonstrating the threshold performance targets. Develop and demonstrate the feasibility of concepts to extend the performance of the device to meet objective performance targets of operation at 1.5 THz with 10 W output power, 20 dB gain, 67% bandwidth, 50% power efficiency, and predicted reliability of one million hours from a single, compact device. Deliverables will include a Phase II final report including complete documentation of the prototype test results, a detailed plan for demonstrating a hardware prototype that can meet the performance metrics listed above, along with applications and prospective partners for technology transfer in Phase III.

PHASE III DUAL USE APPLICATIONS: Achieve a technology readiness level sufficient to support transition to military, civilian, and commercial applications for high power amplifiers (typically TRL 6). A successful Phase III development will demonstrate a hardware prototype based on Phase II design and meeting the objective performance targets and deliver the prototype with complete documentation to a commercial transition partner for applications in communications and sensing.

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KEYWORDS: Beam-wave interaction structure, beam collector, electron source, vacuum electronics

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SB162-007 TITLE: Integrated Interface Layer for Micromagnetics and RF Computational Engines

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Create a Graphical User Interface (GUI) with integrated pre- and post-processors that interface with efficient and accurate nonlinear micro-magnetic computation engines and allow rapid virtual prototyping of nonlinear magnetic components within standard RF design tools.

DESCRIPTION: There is a critical DoD need for capabilities that would provide improved interface of nonlinear micro-magnetic computation engines with standard RF design tools. Electromagnetic modeling and simulation engines are indispensable tools that enable rapid prototyping of components and systems. Linear magnetic behavior of components, such as circulators and oscillators, is efficiently and accurately modeled using any of a variety of standard RF computational engines, including circuit simulators such as Keysight Advanced Design System (ADS) and SPICE. However, these RF computational engines become inefficient and inaccurate for nonlinear and time-dependent magnetic behaviors, thus excluding magnetic components with those signal processing capabilities from the components inventory of RF design engineers. Some of the nonlinear magnetic components of potential value to many RF design engineers include frequency selective limiters (FSL) and signal-to-noise enhancers (SNE), which are self-adaptive (frequency and amplitude) notch and bandpass filters, respectively. Accurate and efficient modeling of the nonlinear and time-dependent magnetic behavior of components such as FSLs and SNEs requires micromagnetics computation engines that operate at the fundamental materials level, which are relatively of insignificance to RF design engineers. In addition, micromagnetics tools are not designed to interface with any specific RF computation engine and tend to produce output data that can be difficult to interpret. This renders micromagnetics tools impractical to RF design engineers and restricts their use, and thus the adoption of self-adaptive components. This impediment can be eased with a user interface capable of interfacing efficiently with both micromagnetics and RF computational engines. As such, this topic calls for innovative solutions for a Graphical User Interface (GUI) with integrated pre- and post-processors that gives the operator an efficient means to set up modeling and simulation problems and scenarios, which includes nonlinear magnetic components, and provides a vehicle for visualization and intuitive interpretation of the simulation output data. The GUI should work with existing RF computation engines and be scalable and robust enough for commercial and military users.

PHASE I: Select one or more candidate RF computation engines and determine input and output data exchange requirements with a high level micromagnetics computation engine. Develop initial concept design for and identify key elements of a GUI with integrated pre- and post-processors to generate input data and display output data for the candidate RF computation engines. Determine technical feasibility of integrating the proposed GUI with the selected computational engines. Deliverables will include a Phase I final report with draft use case, requirements, and implementation documents supporting the proposed integration strategy.

PHASE II: Develop prototype GUI code and demonstrate the capability to generate input data and display output data with the selected RF computational engines. Demonstrate the capability to set up, analyze, and display a simple nonlinear magnetics component, such as an FSL, and validate the simulation results using experimental data or analytical results. Deliverables will include a Phase II final report, prototype GUI source code with complete use case, requirements, and implementation documents, and validation results showing the accuracy and efficiency of the prototype GUI.

PHASE III DUAL USE APPLICATIONS: Produce a fully integrated and optimized GUI, with complete technical and user documentation, supporting one or more selected RF computational engines using the prototype GUI source code from Phase II. Provide GUI source code to DoD laboratories for evaluation and testing. Demonstrate the capability to set up, analyze, and display results from a complex nonlinear magnetics component structure, which will accelerate the design cycle for components critical to electromagnetic communications and sensing applications in the commercial and military sectors.

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KEYWORDS: Electromagnetics, GUI, Micromagnetics, Modeling and simulation, RF circuit simulator

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SB162-008 TITLE: Distributed Coherent Communications

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Establish practical approaches to achieve distributed coherent communications between two disaggregated groups of RF communications nodes.

DESCRIPTION: There is a critical Department of Defense (DoD) need to create and exploit distributed coherent communications to enable future defense operations to make greater use of small, disaggregated, collaborative elements in contrast to larger elements. The challenge of communicating between clusters of such nodes becomes more acute as their size, weight, and power is reduced, in all environments (air, ground, maritime). The ability to create and exploit distributed coherent communications can be of great benefit to meeting these challenges. The reason for this is that a phase coherent array of n RF transmitters can enhance the power received at a distant receiver by a factor of n^2 relative to a single radio [1]. If the receiver also contains an array of m elements, a factor of (n^2)m power gain can be achieved in one direction, and (m^2)n in the other direction. In a symmetric system, n^3 gain is possible. For example, a distributed coherent collection of 10 transmitters communicating to 10 receivers can ideally reduce the power required of a single transmitter by a factor of 1000. This project is aimed at maximizing the ability to exploit this phenomena.

In systems that are not physically connected, the separate challenges of 1) phase coherence between the transmitters, 2) RF channel state measurement, and 3) coordinated sharing of the information communicated must be resolved. While topics associated with coherent communications between groups of users and a centralized base station have been considered in the past, the case of communication between two disaggregated groups is more challenging [2,3,4]. Innovative and practically implementable solutions to these challenges are sought such that the size, weight, and power of the communicating clusters is minimized for a given data rate and operating frequency.

PHASE I: Develop an initial concept design and model key elements of all 3 challenges, and analyze the resulting communication systems properties. Phase 1 deliverables shall include a final report that contains design concept and architecture for a group to group communication system; results of simulation and modeling to establish system feasibility; and a plan for an experimental demonstration of a group to group coherent communication system.

PHASE II: Develop and demonstrate the efficacy of a distributed coherent communications system operating between two self-organizing clusters of nodes. An exemplary demonstration would include n airborne nodes over a variety of link ranges exhibiting n^(3/2) range enhancement relative to a single pair of nodes. Such a system will utilize a local network to establish and maintain communicating groups and to coordinate information transmission between the distant groups. A means for establishing and maintaining coherence among participating users and across groups will be developed. Groups of at least 3 members will be shown, with a preferable goal of 10 group members. Groups shall be flexibly assembled and members may join and leave the assembly in an ad hoc fashion. Phase 2 deliverables shall include the demonstration event, the hardware and software used to effect it, and final report describing the results, a comparison to theoretical expectations, identification of steps needed for further maturation of the technology and open issues or challenges to taking them.

PHASE III DUAL USE APPLICATIONS: Emergency responders often have a need to communicate in challenging conditions where conventional cellular communication infrastructure may be damaged or destroyed. In such conditions, the ability to communicate between disparate groups of radio-equipped users may be essential. The use of reach-enhancing techniques may be essential in these conditions.

Ad hoc communicating clusters of airborne nodes can be used to reduce power demands of autonomous unmanned aircraft systems (UAS) swarms or other collections of small disaggregated sensors. In such environments, small, affordable, stand-in platforms may be called upon to communicate results of intelligence, surveillance, and reconnaissance information. The use of distributed coherent group-to-group communications methods may significantly reduce the size, weight, and power burden that would otherwise be required on a single platform. A similar need arises for separated groups of soldiers communicating in austere environments.

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4. “Distributed Transmit Beamforming Using Feedback control,” R. Mudumbai, J. Hespanha, U. Madhow, G. Barriac, IEEE Trans. Information Theory, v.56 (3), 2010, p.411.

KEYWORDS: multiple-input, multiple-output (MIMO), coherent communications, RF systems, data links

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SB162-009 TITLE: Software/Analytics Exploiting Commercial Satellite Imagery

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Information Systems, Sensors

OBJECTIVE: Develop and demonstrate innovative methods to for leveraging commercially-available satellite imagery data for use in national security applications.

DESCRIPTION: There is a critical DoD need for improved large scale situational awareness that can be addressed by leveraging the growing availability of public and commercial satellite imagery and sensor data. Access to commercial and public satellite imagery and sensor data enables the development of data analytics applications throughout the public and private sectors. Users are able to monitor weather events, crop growth, natural resource harvesting (e.g., mining and logging), urban growth, and many other natural and human-driven activities worldwide. In many cases, data is available with little delay between observation and data delivery. The data can be used for time critical applications such as natural disaster impact predictions and assessments as well as near- and long-term applications such as famine prediction, regulatory and international law compliance assessment, new infrastructure demand evaluation, food and natural resource availability assessment, and regional stability evaluation.

The same commercial and public satellite imagery and sensor data may also be beneficial for DoD and national security related applications, particularly when used to augment other data. Commercial satellite imagery combined with other intelligence can support international drug interdiction, maritime security, and treaty compliance. Further, the use of unclassified satellite imagery and data enables greater sharing of analysis products with non-DoD US agencies and coalition partners for conducting joint operations.

PHASE I: Develop a system concept and software architecture for applications of commercial and public satellite imagery and sensor data for DoD, US interagency, and/or US-supported coalition missions. Develop algorithmic approaches that enable monitoring, prediction, and assessment capabilities for the selected application or mission. Identify metrics, constraints, and performance levels needed for supporting the selected applications and missions, including data distribution approaches. Develop and demonstrate a limited-functionality prototype of the software system. Applications may use a single data source/type (e.g., imagery) or a combination of sources/types. Phase I deliverables shall include a final report that describes the system concept and software architecture, algorithms, and experiment and demonstration data.

PHASE II: Develop, demonstrate, and validate a prototype software solution. The prototype should focus on information collection, analysis, and analysis product dissemination at the appropriate time scales. Conduct tests of the system (software, data collection and distribution, etc.) to show performance relative to established metrics and associated requirements (processing, data access/exchange, and networking) for a deployed application. Phase II deliverables shall include a final report that contains the final system and software architecture, a prototype that has been tested in a realistic environment, test and measurement data, and system functionality and performance analysis.

PHASE III DUAL USE APPLICATIONS: Commercial applications: System architecture and software enabling information collection, analysis, and analysis product dissemination at the appropriate time scales required for application support.

DoD/Military applications: Ability to support DoD, US interagency, and/or US-supported coalition missions.

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2. Longley, Paul. Geographical Information Systems and Science. Wiley, 2005.

3. Lewis, James A., Commercial Satellite Services and National Security: We are Not Alone. Center for Strategic and International Studies, March 2003.

KEYWORDS: satellite imagery, geographic information systems, data analytics

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SB162-010 TITLE: Near-Photon-Counting, High Dynamic Range, Passive Vision Detector Arrays

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop low-light passive imaging sensor technologies based on Linear-mode (Lm) and/or Geiger-mode (Gm) avalanche photodiode (APD) technologies.

DESCRIPTION: This effort will explore Lm and/or Gm APD techniques for a near-photon-counting near infrared (NIR) and/or short wave infrared (SWIR) sensor. The low-light imaging sensor should operate in bright sunlight with a large single-detector instantaneous field-of-view (IFOV), and also operate at night with very low ambient light, with sensitivity better than current night vision and low-light sensors by several orders of magnitude. DARPA is interested in developing a photon counting sensor detector array for passive imaging with incoherent illumination, operating in either the linear mode or Geiger mode. The minimum desired array size is 128x128 detectors, and the array technology should be capable of scaling up to 1028x1028 detectors. The array should be capable of passive light detection at frame rate > 30 Hz. The detectors should have an avalanche gain > 100, with an excess noise factor < 2. The sensor should be capable of storing 10 or more range returns per angle/angle pixel when in a receiver mode. Detector pitch should be 50 µm x 50 µm or smaller. The detectors should come as close as possible to detecting 1 photon with a high detection probability and a low false alarm rate. The detectors should have bandwidth > 500 MHz. The detector array should be capable of a FOV > 35 x 35 degrees in bright sunlight in the 800-1200 nm and/or 1500 -1600 nm bands, using passive direct detection with a narrow band filter that is > 3 nm in width. More angle/angle pixels will reduce the need to handle high background radiation in a particular detector. One of the goals of this effort is a passive imaging sensor with high dynamic range in the presence of high daylight background illumination. Another goal is a passive imaging sensor that also has high sensitivity at night with very low ambient flux. The sensor should be capable of incorporating a narrowband filter for operation with active laser illumination, and also a much broader wavelength filter for passive operation. In order to allow the possibility of coherent sensor operation with a strong local oscillator (LO), the sensor readout should be AC coupled or provide some other readout method so the detector dynamic range through narrowband filer or wideband filer operation is not significantly reduced when a strong LO is used. The sensor should be capable of integration into a compact and inexpensive imaging system with minimal required cooling/temperature control hardware.

PHASE I: Develop a detailed description of the detector array and photon counting imaging sensor system capable of operating in NIR or SWIR bands, and should result in a description of the low light imaging performance under extreme low light conditions, a description of the dynamic behavior and electrical properties of the sensor system and a preliminary evaluation of the expected size, weight, and power consumption of a prototype implementation. Phase 1 should address the ability of the proposed approach to operate in bright sunlight with only a moderately narrowband filter and a wide FOV, and should estimate how many photons at a single detector pixel would be required for 90% probability of detection (PD). A single pixel should generate false detections at rate < 1 per minute, and an object which aggregates > 60 pixels should generate a false object detection at rate < 1 per hour.

PHASE II: Demonstrate the Phase I concept via laboratory breadboard experiments. In Phase 2, a Phase 1 concept will be reduced to practice and performance validated in a laboratory setting. The experiments conducted should result in empirical and/or analytic knowledge that is used to design a preliminary prototype sensor. The laboratory brassboard must provide characterization data that demonstrate by analysis that the performance objectives can be met. The preliminary design should focus on a demonstration system which could be utilized in a field experiment and would directly meet the performance objectives.

PHASE III DUAL USE APPLICATIONS: The Phase 3 effort should build the preliminary prototype sensor and conduct a field demonstration meeting the performance objective. A Phase 3 demonstration could be applied to a number of commercial applications, including for example: 1) An automobile day/night passive sensor for a driverless car, 2) a lidar sensor for measuring body motions in interactive computer games, and 3) compact day/night passive or active (i.e. lidar) surveillance systems for robotics and/or security. A commercially-focused Phase 3 effort could choose a viable commercial use and build a prototype system optimized for that application.

The Phase 3 effort for DOD application should result in development of an extremely sensitive and flexible integrated day and night capable 2D/3D vision system that will be able to operate in full day light and extreme low light conditions seamlessly. Additionally, the Phase 3 effort will fill the large need for Unmanned Aerial Vehicle (UAV) sensors, and sensors for robots that require full daylight and extreme low light operations. The Phase 3 effort will be able to fabricate short range, inexpensive, relatively wide FOV sensors in large quantities. The Phase 3 effort should provide advanced passive and active low light imaging sensor options that also can be used with other 3D lidars, UAVs, and robots. Example tasks with military application for these systems may include day/night autonomous navigation, night time surveillance, terrain mapping, and improved night vision for vehicle operators and ground troops.

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2. T. Vogelsong; J. Tower; T. Senko; P. Levine; J. Janesick; J. Zhu; D. Zhang; G. van der Wal; M. Piacentino, “Low-light NV-CMOS image sensors for day/night imaging”, Airborne Intelligence, Surveillance, Reconnaissance (ISR) Systems and Applications X, SPIE Vol. 87130F (31 May 2013)

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4. P. F. McManamon, Chair, W F. Buell, co-chair, et al, “Laser radar, Progress and Opportunities in Active EO sensing”, National academy of sciences report, International Standard Book Number-13: 978-0-309-30216-6 International Standard Book Number-10: 0-309-30216-1

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KEYWORDS: Low Light Imaging Sensor, Low Light Receiver, Avalanche Photo Diode, APD, Linear mode APD, LMAPD

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SB162-011 TITLE: Distributed, Large Scale Spectrum Measurement and Analysis

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Electronics, Information Systems

OBJECTIVE: Develop and demonstrate innovative methods to collect, process, and analyze RF spectrum measurements made from a large number (50 or greater) of mobile collection platforms (at low altitude and/or close to the emitters) to obtain useful information on spectrum use and activities.

DESCRIPTION: There is a critical DoD need to obtain radio operations information using spectrum measurements. The Internet of Things devices and the proliferation of low power communication devices are becoming an increasing factor in wireless operations. Many of these systems use directional signals and operate at high frequencies. These factors make these signals unobservable at large standoff distances. In cases where these signals are detectable, the number of signals detected tends to overwhelm any signal processing system.

It is of interest to use large (10s to 100s) numbers of small, low cost platforms to carry a small spectrum collection and processing sensor to provide distributed, wide area coverage for spectral sensing and radio operation understanding. This would solve both the problems of making an individual system “disposable” and detecting weak signals possible. There are other advantages such as spatial diversity detection (receiving signals simultaneously from many spatial angles), location diversity (seeing signals from many locations), etc. The platforms of interest can include airborne and ground platforms.

The challenge is that a mobile platform near a transmitter or flying at low altitudes (to avoid detection) measures a signal with rapidly varying amplitudes and small detection distance. Combining these problems with uncertain or unknown transmitter parameters (duty cycle, antenna pointing angle, antenna beam motion, waveform agility, etc.) makes mobile platform spectrum data interpretation very difficult. Another challenge is that small mobile platform sensors have limited spectrum scan rate, processing, and backhaul capabilities. These limitations need to be managed to achieve useful mission selectable goals.

PHASE I: Develop a system design concept, including the sensor platform, networking approach, and application functionality. Perform technology risk reducing experiments and demonstrations of system components if possible. Develop algorithms and software to enable obtaining useful information on transmitters (characteristics, locations, mobility, etc.) from the distributed measurements.

PHASE II: Develop, demonstrate, and validate a prototype distributed mobile spectrum measurement system. The prototype should focus on mobile airborne platforms, but the demonstration may involve live ground platforms along with emulated data from airborne sensors for cost efficient tests. The demonstration should include real and emulated sensors to show scalability (goal of 50 nodes).

PHASE III DUAL USE APPLICATIONS: Commercial applications: Continue to mature the design by adding features to meet requirements for commercial applications in spectrum monitoring and enforcement in industries such as telecommunications and broadcasting. The testing should include common commercial UAV platforms.

DoD/Military applications: Continue to mature the design by adding features to meet more military requirements, including testing on common military unmanned and manned airborne platforms. Investigate the potential for transitioning portions of the technology to existing programs of record.

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2. SiXing Yin; Dawei Chen; Qian Zhang; Mingyan Liu; ShuFang Li, "Mining Spectrum Usage Data: A Large-Scale Spectrum Measurement Study," Mobile Computing, IEEE Transactions on, vol.11, no.6, pp.1033,1046, June 2012.

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KEYWORDS: communications, sensors, electromagnetic spectrum, jamming, electronic warfare, signals intelligence

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SB162-012 TITLE: Complementary Piezo Energy Harvesting for Small Satellites in Eclipse

PROPOSALS ACCEPTED: Phase I Only

TECHNOLOGY AREA(S): Materials/Processes, Space Platforms

OBJECTIVE: Demonstrate a piezo energy harvesting system (PEH) for a cubesat or similar small satellite platform that complements existing photovoltaic elements, trickle-charging the spacecraft's batteries in periods of eclipse when photovoltaic output is low, thereby reducing the required spacecraft battery capacity.

DESCRIPTION: The Department of Defense has a critical need for greater availability of timely services provided by space-based assets. These services range from communications to navigation and overhead imagery. New service offerings depend upon more capable and resilient small satellites that may be launched more frequently and at lower cost relative to traditional space systems. Battery size (capacity) requirements for satellites are determined in part by system energy needs. Significant stored energy is necessary to power subsystems while the spacecraft is in the nighttime portion of the orbit when solar panels are in eclipse and receive little sunlight.

To realize the next generation of highly capable small satellites, the mass fraction of batteries must be reduced. Adapting energy harvesting systems originally developed for terrestrial utility and wearable electronics applications have been proposed to complement improvements in battery energy density and solar cell efficiency.

Piezo energy harvesters (PEHs) convert the kinetic energy of structural vibrations or oscillatory motion to useful electricity. When PEHs are subjected to a harmonic mode, piezoelectric composite material segments embedded in the structure periodically deform, thereby generating electricity. An initial perturbation is typically delivered from the thermally induced release of strain energy in a bistable mechanism with spring- and/or shape-memory-alloy storage member. Following the perturbation, multifunctional structures attached to the spacecraft that incorporate photovoltaics, sensors, and PEH structures may freely vibrate, thereby charging the batteries.

PEH systems for satellites must overcome several technical challenges to be practical. First, new piezo composite transducers must be engineered that exhibit greater current density under large strain, on the order of mA/g, resulting in a measurable reduction in the required battery size. Second, the mechanism that applies the perturbation and the PEH smart structure dynamic properties (mass, effective stiffness, and damping) should be engineered for an oscillation that decays over a period of time comparable to the nighttime portion of the orbit. It should also be capable of being passively reset during the daytime portion of the orbit. Third, the multifunctional smart structure containing the PEH system must not add more than 2 percent to the spacecraft total mass budget. Lastly, the system must operate in a manner that does not adversely affect spacecraft attitude control or introduce excessive jitter in imaging sensors.

Innovative solutions are sought to these problems, leading to the first operational small satellite PEH system. The PEH prototype is envisioned to be demonstrated on the ground in an evacuated neutral gravity environment, and in low Earth orbit (LEO) on board a 6U cubesat or similar small (less than 50 kg) satellite.

PHASE I: Design a small satellite with a technically feasible multifunctional smart structure that supports photovoltaics and the PEH system with supporting sensors and rectification electronics. Design a passive perturbation mechanism that can be reset upon emerging from eclipse. Verify the PEH system is energy-positive and calculate the system output in watts and the corresponding reduction in the required spacecraft bus battery capacity. Power budget calculations should be based on a notional small satellite with visible spectrum imaging payload. Analyze the free-vibration transmissibility to the payload, assuming nominal damping properties, and estimate the impact on sensor jitter and platform accelerations in six axes. Phase I deliverables include a preliminary design report that contains the mechanism design, system output and predicted savings in battery capacity.

PHASE II: Prototype the proposed PEH smart structure with perturbation mechanism and demonstrate on the ground in an evacuated neutral-gravity environment. In addition to basic functionality, verify dynamic properties (mass, stiffness, damping ratio, logarithmic decrement, natural frequency), PEH system power output, and total energy conversion efficiency (i.e., thermal-to-kinetic, plus kinetic-to-electrical). Measure vibration transmissibility to a representative sensor mass mock-up. Phase II deliverables include the working system prototype and critical design report with experimental characterization results.

PHASE III DUAL USE APPLICATIONS: The mature PEH system may be incorporated in the next generation of small military or commercial overhead imaging satellites that deliver near-real-time imagery to the warfighter. The reduced battery capacity enabled by the PEH system means more power available for on-board image processing or more mass available for payloads. The technology may also be applied in strategic naval applications, where PEH components attached to a sea bed deliver power to an unmanned undersea vehicle-charging station. Integrate the PEH system smart structure into a 6U cubesat or similar commercial off-the-shelf (COTS) small satellite (<50 kg) bus. Launch the satellite as a ride share to LEO and verify functionality, including sensor jitter and platform accelerations while the system is in operation.

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KEYWORDS: Vibration, energy harvesting, satellite

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SB162-013 TITLE: Telemetry Buoy - TM Collection System

PROPOSALS ACCEPTED: Phase I Only

TECHNOLOGY AREA(S): Electronics, Ground/Sea Vehicles

OBJECTIVE: Identify, develop and demonstrate new, inexpensive, user-friendly methods for autonomous telemetry (TM) collection with improved link margin and improved redundancy from flight test assets traversing large open-ocean distances.

DESCRIPTION: Long-range, open-ocean flight tests currently require a large number of telemetry collection assets—usually a combination of airborne, seaborne or land-based—spread across the flight path, resulting in increased costs, schedule and logistics concerns. Future flight tests could benefit from inexpensive telemetry collection assets that could be easily and quickly deployed and could either store the data for later pickup, or retransmit the data on command.

This problem could potentially be addressed by small buoys, or autonomous ocean-going vessels with the appropriate telemetry collection receivers and antennas, recorders (if necessary) and re-transmission systems (if necessary). These unmanned systems could either be placed or maneuvered directly under the planned flight path, less than 50-miles from the transmission source as it flies overhead, and if inexpensive enough, could be placed with relatively short spacing between assets to improve link margin and improve redundancy.

PHASE I: Determine technical and economic feasibility of a telemetry collection buoy, develop a plan for practical deployment, and produce a conceptual design of this system. Phase I deliverables would include a final report showing the assessment of the technical and economic feasibility and a draft concept of operations of the proposed system. Additionally a conceptual design document and proposed system requirements to guide subsequent development would be required.

PHASE II: Develop, test and demonstrate the system via an operational prototype. Required Phase II deliverables would include concept of operations (CONOPS), requirements documentation, design documentation, test plan and test reports.

PHASE III DUAL USE APPLICATIONS: Any future flight testing of long- range flight vehicles having limited payload and telemetry capabilities will require testing over open-ocean ranges where telemetry (TM) assets are either sea-borne, airborne, or overhead. A low-cost operational TM buoy would enable simple telemetry collection for these critical tests.

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KEYWORDS: Telemetry, flight test, buoys, autonomous ocean-going vessels, hypersonics

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SB162-014 TITLE: Light-weight and Low Cost Composite Cryotank

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Air Platform, Space Platforms

OBJECTIVE: Develop high-performance, lightweight composite cryogenic propellant tanks suitable for use on expendable and reusable space access vehicles and hypersonic aircraft.

DESCRIPTION: While advancements in composite pressure-vessel technology have allowed the fabrication of composite cryogenic propellant tanks, the state of the art falls far short of what is currently possible with propellant tanks in terms of performance and reusability.

Existing graphite-fiber composite-pressure vessels can safely operate without leaks with multi-axis strain levels in excess of 15,000 microstrain, however conventional graphite-fiber composite cryotanks tend to operate at less than 5,000 microstrain [Ref 1]. This means that these cryotanks tend to be three times heavier than a pressure vessel designed for the same operating pressure. Achieving 15,000 microstrain in a graphite-fiber composite cryotank would offer the capability to achieve tank weight/volume that is far less than the metal cryotanks currently in use in space launch vehicles [Ref 2], enabling improved vehicle performance and payload delivery.

In this effort, DARPA seeks very low-cost and lightweight composite cryotanks that offer substantially better cost and weight/volume than state-of-the-art tanks. The target performance is to achieve a recurring production cost of less than $1,000/ft3 internal volume and less than 0.50 lbm/ft3 (weight of tank/volume of tank) performance in a reference cryotank that is 6 ft. in diameter with a volume of 350 ft3, assuming a minimum burst of 120 psi, not including structural load bearing skirt extensions. The cryotank needs to remain leak-tight after repeated cryogenic temperature and pressure cycles, with a minimum threshold of 25 combined cycles and a goal of more than 1,000 combined cycles. The cryotank must be capable of operating with common rocket propellants, with a minimum threshold of liquid oxygen (LOX), RP-1 and liquid methane containment capability and a goal of liquid hydrogen capability.

PHASE I: Experimentally demonstrate the capability of a thin graphite-fiber composite laminate to remain leak-tight when subjected to repeated multi-axis strain and thermal cycles. Specifically, the testing would need to demonstrate leak-tight capability after at least ten combined thermal (less than LOX temperature) and multi-axis strain (greater than 15,000 microstrain) cycles. Using test results, develop a conceptual design of a cryotank that would demonstrate the weight/volume goal for the reference tank requirements. Show how the cryotank could be adapted to include structural load-bearing capability and assess the performance impact.

PHASE II: Design, analyze and fabricate cryotanks that meet the reference tank requirements. Test the cryotank to verify that it achieves the weight/volume goal and remains leak-tight after more than the threshold number of combined thermal (at liquid nitrogen (LN2) temperature) and pressure cycles (design operating pressure).

PHASE III DUAL USE APPLICATIONS: Achieving the composite cryotank cost and weight/volume performance goals cited in phase 2 and 3 above offers the means to reduce launch vehicle mass and increase launch vehicle payload while reducing cost. Achieving the combined cycle goal would provide this performance advantage to reusable vehicles, thereby reducing launch costs. The technology is directly applicable to follow on reusable vehicles to DARPA's Experimental Spaceplane (XS-1) program, as well as next-generation global reach and advanced hypersonic aircraft.

This technology would support a wide range of commercial launch vehicles being pursued today, both expendable and even a few reusable vehicle concepts. The technology would also support advanced hypersonic aircraft and airborne laser systems as well as liquefied natural gas transportation systems.

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KEYWORDS: Additive Manufacturing, Liquid Rocket Engines, Launch Vehicle, Spacecraft Propulsion

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SB162-015 TITLE: Autonomous Detection of Near-Surface Marine Mammals

PROPOSALS ACCEPTED: Phase I and DP2. Please see the 16.2 DoD Program Solicitation and the DARPA 16.2 Direct to Phase II Instructions for DP2 requirements and proposal instructions.

TECHNOLOGY AREA(S): Ground/Sea Vehicles, Sensors

OBJECTIVE: Develop and demonstrate a reliable autonomous methodology to detect, localize and identify presence of marine mammals from transiting surface ships at ranges up to 1,000 yards. Investigate and validate the necessary combination of sensors, software and computing to achieve this desired objective.

DESCRIPTION: Under the provisions of the Marine Mammal Protection Act, and as good stewards of the natural environment, it is incumbent on all U.S. mariners, including operators of DoD vessels, to avoid strikes and "near misses" of whales and other mammalian species. Current methods of performing this task primarily rely on human watchstanders using binoculars. This is less than ideal even in conditions of good visibility, since humans are subject to fatigue and inattention, and marine mammals may only surface for fleeting periods of time. In conditions of poor visibility, the potential for overlooking presence of mammals increases. It is possible that automated solutions, either instead of or in addition to human observers, may be more effective than current methods.

This SBIR seeks to derive innovative marine mammal detection solutions to establish autonomous means of:
• Marine mammal identification to abate vessel strike of transiting ships
• Marine mammal mitigation zones around each vessel using sonar
• Reducing inherent human error for accurate detection of marine mammals

PHASE I: Determine technical feasibility of detecting and identifying marine mammals from a transiting surface ship using best-of-breed sensors and processing. Investigate available spectrum of most-effective active and passive sensors to discriminate a marine mammal from other natural sea clutter.

Determine the technical feasibility of automating the detection and identification of marine mammals using the detection methodology specified above.

Phase I deliverables shall include analysis of alternatives of sensor(s) detection methodology with recommended solution. Additional deliverable is analytical (algorithm development) approach and study to achieve autonomous and reliable marine mammal detection and identification.

PHASE II: Finalize Phase I deliverables into an engineering design, including software development plan. Demonstrate and validate detection and identification of marine mammals from a transiting surface ship using Phase I-derived sensor(s) and processing.

Phase II performance metrics shall be achieved through construction of engineering prototype sensor(s) suite to collect specific data required to validate marine mammal detection and identification algorithms.

The complex sensor-processing Phase II solution shall demonstrate the ability to discriminate a marine mammal from other natural sea clutter.

Phase II deliverables shall include refined analysis methodology with recommended Phase III demonstration. Additional deliverable is analytical (algorithm development) approach and study to achieve autonomous and reliable marine mammal detection and identification.

PHASE III DUAL USE APPLICATIONS: The sensor system and software developed in this topic could be packaged to provide a marine mammal warning and avoidance system for commercial vessels, reducing the incidence of marine mammal strikes and near misses, aiding commercial operators in their obligations under the Marine Mammal Protection Act.

REFERENCES:
1. The Marine Mammal Protection Act of 1972 as Amended.

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